

## **SECTION 34 21 60**

### **GROUNDING AND BONDING FOR TRACTION POWER FACILITIES**

#### **PART 1 – GENERAL**

##### **1.01 SECTION INCLUDES**

- A. Grounding and bonding equipment.
- B. Grounding rods.
- C. Bare conductors.
- D. Bus bar of ground test station.
- E. Single conductor insulated wire.
- F. Terminal lugs.
- G. Jumpers.
- H. Bolts and miscellaneous hardware for grounding.
- I. Safety ground wire mesh.
- J. Fiberglass reinforced thermoset polyester molded material.

##### **1.02 RELATED SECTIONS**

- A. Section 01 43 00, Quality Assurance
- B. Section 01 45 00, Quality Control
- C. Section 01 21 23, Field Engineering
- D. Section 01 33 00, Submittal Procedure
- E. Section 01 33 23, Shop Drawings, Product Data, and Samples
- F. Section 01 74 14, Cleaning
- G. Section 01 77 00, Closeout Procedures
- H. Section 01 78 39, Contract Record Documents
- I. Section 01 79 00, Demonstration and Training
- J. Section 01 45 24, Testing Program Requirements, for requirements
- K. Section 20 70 26, Common Material and Methods for Electrical System
- L. Section 20 80 00, Systems Integration Testing

- M. Section 34 21 01, General Requirements for the Traction Power System
- N. Section 26 05 24, Low Voltage Wires and Cables
- O. Section 34 21 50, Common Materials and Methods for Traction Power
- P. Section 34 21 70, Traction Power Facilities Installation Requirements
- Q. Section 34 21 80, Traction Power System Field Acceptance Testing

### **1.03 MEASUREMENT AND PAYMENT**

- A. General: Grounding and bonding will not be measured separately for payment but will be paid for as part of the Contract lump sum price for the related item of work as indicated in the Bid Schedule of the Bid Form.

### **1.04 REFERENCES**

- A. American National Standards Institute (ANSI)
  - 1. ANSI Z55.1 Grey Finishes for Industrial Apparatus
- B. American Society for Testing and Materials (ASTM):
  - 1. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
  - 2. ASTM B3 Specification for Soft or Annealed Copper Wire
  - 3. ASTM B187 Specification for Copper Bar, Bus Bar, Rod and Shapes
  - 4. ASTM D495 Standard Test Methods for High Voltage, Low Voltage Arc Resistance of Solid Electrical Insulation
- C. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. IEEE 80 IEEE Guide for Safety in AC Substation Grounding
  - 2. IEEE 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
  - 3. IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
  - 4. IEEE 837 Qualifying Permanent Connections Used in Substation Grounding
  - 5. IEEE 1100 IEEE Recommended Practice for Power and Grounding Electronic Equipment

- D. Underwriters Laboratories Inc. (UL)
  - 1. UL 486                    A & B Wire Connectors
  - 2. UL 467                    Grounding and Bonding Equipment
- E. California Code of Regulations
  - 1. Title 24, Part 3        California Electrical Code
- F. National Electrical Manufacturers' Association (NEMA):
  - 1. VE 1                    Metal Cable Tray Systems
  - 2. VE 2                    Cable Tray Installation Guidelines
- G. National Electrical Contractors' Association (NECA):
  - 1. NECA 607                Standard for Telecommunications Bonding and Grounding  
Planning and Installation Methods for Commercial Buildings
- H. National Fire Protection Association (NFPA) Standards
  - 1. NFPA 70                National Electrical Code
  - 2. NFPA 780                Standard for the Installation of Lightning Protection Systems

## **1.05 SUBMITTALS**

- A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Shop Drawings: Submit detailed Shop Drawings including, but not limited to, the following:
  - 1. Master Drawing Index.
  - 2. Grounding Diagrams.
  - 3. Grounding grid plans depicting locations of ground rods, embedded and buried grounding conductors, ground wells, locations of stub outs and grounding connections, safety wire mesh mats and locations of stub outs and pigtails for future connections to the grounding system by others.
  - 4. Exposed grounding plans depicting locations of ground test stations, ground risers, and ground conductor routing.
  - 5. Typical grounding details showing electrical systems, equipment, metallic conduit/cable tray and noncurrent carrying conductive entity grounding and bonding connection.

6. Drawings shall indicate locations of test points to measure grounding resistance.
- C. Product Data: Submit manufacturer's product data sheets including, but not limited to, the following:
1. Ground conductors.
  2. Connectors, clamps, terminal lugs, bushings, and fittings.
  3. Exothermic welding process, materials, and molds.
  4. Ground rods.
  5. Ground test stations / busbars.
  6. Ground well boxes.
  7. Standoff insulators.
  8. Flexible braid jumpers.
  9. Coal tar epoxy coating.
  10. Oxide inhibiting compound.
  11. Safety ground wire mesh, if used.
- D. Material safety data sheets.
- E. Test Plans and Procedures: Submit test plans and procedures.
- F. Test Reports: Submit required copies of certified test reports of grounding resistance tests, including method of measurement.
- G. As-built & Records Drawings: Submit as-built and record drawings.

#### **1.06 QUALITY ASSURANCE, QUALITY CONTROL AND SUPPLIER QUALIFICATIONS**

- A. Refer to Section 34 21 01, General Requirements for the Traction Power System.

#### **1.07 DELIVERY, STORAGE AND HANDLING**

- A. Provide marking on wire and cable in accordance with applicable standards. Each item shall be UL-labeled.
- B. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
- C. Store equipment and materials in secure and dry storage facility.

**PART 2 – PRODUCTS****2.01 EQUIPMENT AND MATERIALS**

- A. Grounding and Bonding Equipment, Components and Materials: Conform to UL 467, IEEE 837 and the additional requirements specified herein.
- B. Ground Rods: Medium carbon steel core, copper-clad by the molten weld casting process, size of 1"x10'-0" (one inch in diameter by ten feet in length) long or as indicated, UL listed.
- C. Bare Conductors: ASTM B3, Class B stranded, annealed copper conductor, unless otherwise indicated, size as indicated.
- D. Bus Bar: ASTM B187, 98 percent conductivity copper, size as indicated.
- E. Standoff Insulators (for bus bars): UL rated and constructed from flame retardant, glass reinforced thermoset polyester compound with a current carrying capacity for the intended application in accordance with ASTM D495.
- F. Single Conductor Insulated Wire: Refer to Section 26 05 24, Low Voltage Wires and Cables. Use insulated ground wire for grounding communication and train control systems.
- G. Terminal Lugs: Refer to Section 34 21 50, Common Materials and Methods for Traction Power.
- H. Jumpers: Tin plated copper, braided, flexible jumper.
- I. Bolts and miscellaneous hardware for grounding: Material shall be silicon bronze.
- J. Ground rod clamps: Corrosion resistant silicon bronze clamps with screws.
- K. Universal perimeter gate / fence pipe clamps: Highly conductive thinned copper with feature stainless steel hardware
- L. Cable Connectors (for enclosures without ground lugs): Highly conductive copper alloy.
- M. Oxide inhibiting compound: Non-melting, non-petroleum base material with suspended zinc particles and suitable for application on the intended materials.
- N. Cold galvanizing compound: Corrosion protective zinc coating compliant to ASTM A780.
- O. Safety ground wire mesh: Prefabricated wire mesh, solid copper wire size is No. 6 AWG. All joints of the prefabricated wire mesh shall be silver brazed at the wire crossing points.
- P. Fiberglass reinforced thermoset polyester molded material: NEMA GP0-3, minimum 1/2 inch in thickness, in red. The sizes shall be as indicated.

**2.02 EXOTHERMIC WELDING PROCESS**

- A. Exothermic welding process shall consist of a system of standard manufactured molds for each type of weld to be made and powdered metals that are placed in the mold along with the conductors to be welded. Weld metals shall be of types designed for the types of metals being joined. Ignition of the powder shall produce molten copper, which welds the conductors to each other and to a surface, as the case may be. Exothermic materials and products shall be "CADWELD" manufactured by ERICO Products, Inc, Thermoweld, or equal.
- B. Compression or mechanical type grounding connections are not equal to exothermic welded connections for applications in concealed, underground, wet or damp location, and are not permitted.

**2.03 COAL TAR EPOXY COATING**

- A. Coal tar epoxy shall be used as a protective coating over exothermic welds, if recommended by the weld manufacturer.
- B. Coating shall be polyamide cured coal tar epoxy, applied to 15 mils dry film thickness.
- C. Approved Manufacturers:
  - 1. Carboline Company, Dampney Company, Inc., Tnemec Coating Company, or equal.
- D. Coal tar epoxy coating products shall have the following minimum properties:
  - 1. Minimum volume resistivity of 10<sup>10</sup> ohm-centimeters.
  - 2. Thickness as recommended by the manufacturer for the specified system but not less than 15 mils.
  - 3. Provide a chemical or mechanical bond to the metal. Pressure sensitive or non-bonding systems are not acceptable.
  - 4. Mechanical characteristics capable of withstanding reasonable abuse during handling and installation and earth stresses after installation for the design life of the system.

**2.04 GROUND WELL BOXES**

- A. Precast, high density, reinforced concrete with full traffic covers. All covers shall be slip resistant and marked "GROUND WELL".
- B. Minimum size of 12-inch diameter by 24-inch depth.
- C. Manufacturer: Christy, Brooks Products, or equal.

## PART 3 – EXECUTION

### 3.01 REQUIRED GROUNDING SYSTEM PARAMETERS

- A. At high voltage substations, the ground resistance from equipment or structure to ground well shall not exceed **one Ohm (1  $\Omega$ )**.
- B. At Traction Power substations, the ground resistance from ground test station to earth shall not exceed two Ohms (**2  $\Omega$** ).
- C. For any other systems the total ground resistance shall not exceed **five Ohms (5  $\Omega$ )**.
- D. Provide ground grid conforming to IEEE 80 step and touch potential criteria. Grounding calculations shall consider a 50-kg person and 0.5 second fault clearing time for step and touch potential calculations.

### 3.02 INSTALLATION OF GROUNDING SYSTEM

- A. General:
  - 1. Provide continuous ground / bond conductor or splice using ground/bond connections made in accordance with IEEE 837, NEC, CEC, and the manufacturer's recommendations.
  - 2. Connect substation grounding grid as indicated on the Contract Drawings.
  - 3. Provide separate systems and equipment grounding as indicated.
  - 4. Ground metallic conduits, raceways, under-floor ducts, cable trays, boxes, cabinets, exposed expansion joints, lighting fixtures, and receptacles in accordance with the California Electrical Code.
  - 5. Safety ground wire mesh: Install solid copper wire mesh in accordance with the manufacturer's requirements.
  - 6. Mechanical digging apparatus shall not be used within two feet of any existing underground utility. If existing underground utilities are found during installation of grounding grid system, Contractor shall hand dig all excavations within two feet of the existing underground utility. Bring any existing underground utility unexpectedly encountered to the attention of the Engineer or the Inspector.
- B. Ground Connections:
  - 1. All medium voltage equipment shall be bonded through to the ground grid by a minimum of two bonding conductors.
  - 2. All connections shall be made in accordance with the manufacturer's requirements. All connections shall be cleaned and coated with a bitumastic epoxy before backfilling.

- C. Grounding conductors shall be protected from physical and environmental damage. Wherever possible, grounding and bonding conductors routed in rooms shall be enclosed in a non-metallic raceway. Exposed conductors, which shall extend from a concrete surface, shall be located as close as possible to a corner. Where conductors are required to run exposed, as in the connection to the main ground bus, grounding conductors shall be supported by corrosion resistant metallic hardware at 4-foot intervals or less.
- D. Completely remove all paint, dirt, or other surface coverings at grounding conductor connection points so that good metal-to-metal contact is made. Make connections with clean, bare metal at points of contact.
- E. Service grounds and grounding or bonding of electrical service equipment shall be with continuous un-spliced grounding conductor.
- F. Unless advised to the contrary protect in place the existing ground grids. Repair damage to the existing ground grids at no additional cost to the District.
- G. Protect the exposed ground grid, ground rods, ground conductors, or ground connections from damage and/or theft. Replace damaged and/or lost materials at no additional costs to the District.
- H. Do not route ground conductors and/or place ground rods directly under structures.
- I. Provide exothermic welds for buried or embedded connections. Unless otherwise specified all connections located outdoors, or above ground in damp, or wet locations shall be by exothermic welding. Exothermically weld connections to ground rods. Compression or mechanical connections shall not be used underground. Grounding connections shall not be soldered. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
  - 1. Test all welds by striking with a two-pound steel hammer. Replace all defective, damaged, or loose welds.
  - 2. Test welds for electrical resistance. The completed exothermic weld shall have a resistance equal to or less than a length of cable equal to the length of weld, and the current carrying capacity of the weld shall be equal to or greater than the cable itself. Document electrical resistance.
- J. Compatibility
  - 1. Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - 2. Use electroplated or hot-thin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
- K. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.



- L. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
- M. Coat and seal connections having dissimilar metal with inert material to prevent future penetration of moisture to contact surfaces.
- N. Oxide inhibiting compound shall be used for all mechanical connections where copper to aluminum or copper to steel connections are made. The compound shall be applied to all copper, aluminum, and steel parts. In addition, all aluminum contact surfaces shall be abraded after application of the inhibiting compound, and before attachment of the bolted connection.
- O. Use hydraulic compression tools to provide correct circumferential pressure for compression-type connections. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- P. Lugs
  - 1. Two-hole compression type terminal lugs shall be used to connect grounding conductors to equipment enclosures and ground test stations.
  - 2. For No. 8 AWG and larger, use pressure-type grounding lugs. No 10 AWG and smaller ground conductors may be terminated with winged pressure-type connectors.
- Q. All splice connections shall be made in accordance with the manufacturer's requirements.
- R. If insulated grounding conductors are connected to ground rods or ground test stations, insulate entire area of connection and seal against moisture penetration of insulation and cable.
- S. Connect ground test stations / bus bars to ground system within the traction power facilities. Provide water stops on ground cable risers where the risers enter the structure.
- T. Post backfilling paint exposed bare copper conductors and ground rods ANSI Z55.1; Type 61 light gray.

### **3.03 GROUND RODS**

- A. Bury ground rods vertically with rod top a minimum of 2'-0" below grade or with rod top terminated in a gravel filled ground well. If extensive rock formation is encountered, relocate ground rods to a new location as approved by the Engineer.
- B. Interconnect ground rods longitudinally and laterally with minimum 250 kCMIL stranded bare copper wire or as indicated.

- C. Ground the non-current-carrying metal enclosures with a conductor sized as required by the NEC, CEC.
- D. Connect the grounding conductor to each rod using exothermic welds. In the case of confined spaces (i.e. underground structures) clamp connectors are acceptable to ensure compliance to CalOSHA requirements.
- E. Install supplemental ground rods or other appurtenances to make the grounding system conform to the specified minimum ground resistance requirements.

### **3.04 GROUND WELL BOXES**

- A. Install ground well boxes as indicated in the Contract Drawings.
- B. Install ground rods with ends four inches above a sand backfill with approved exothermic welded connections of grounding conductors fully visible and accessible.

### **3.05 GROUND TEST STATIONS / BUS BARS**

- A. Install ground test station 2'-0" above finished floor and/or finished grade.
- B. Identify each terminated ground conductor (with the associated originating equipment designation) at each ground test station.

### **3.06 GROUNDING CONDUCTORS / WIRES**

- A. Conductor Types:
  - 1. Equipment/Raceway Grounding Conductors: - Insulated with green-colored insulation.
  - 2. Grounding Electrode Conductors: Stranded cable.
  - 3. Underground conductors: Bare, stranded cable.
- B. All grounding wires shall be sized in accordance with the NEC, CEC, and the manufacturer's recommendations to provide adequate conduction path for all possible faults and electrical interference currents.
- C. Route ground conductors / wires along shortest and straightest paths possible, unless specified otherwise. Avoid obstructing access or placing conductors / wires where they may be subjected to strain, impact, or damage.
- D. Bury ground conductors vertically with a minimum of 3'-0" below grade. If site conditions prevent compliance to this requirement request clarification from the Engineer.

**3.07 BONDING STRAPS AND JUMPERS**

- A. Install bonding straps and jumpers so vibration by equipment mounted on vibration isolation hangers or supports is not transmitted to rigidly mounted equipment.
- B. Use exothermic-welded connectors for outdoor locations, unless a disconnect type connection is required, then use a bolted clamp.
- C. Bond straps directly to the structure taking care not to penetrate any adjacent parts.
- D. Install straps only in locations accessible for maintenance.

**3.08 GROUNDING CONNECTIONS TO NON-CURRENT CARRYING CONDUCTIVE ENTITIES**

- A. Ground the non-current-carrying metal enclosures with a conductor sized as required by the NEC, CEC.
- B. Reinforcement Steel
  - 1. Exothermically welded, embedded ground cables and fittings to concrete reinforcing steel shall be secured with steel tie wires to prevent displacement during concrete placement.
  - 2. Electrically bond all reinforcement steel associated with cast in place structures to the traction power facility ground grid.
- C. Ground fencing and other metallic frame structures as follows:
  - 1. Ground metal fencing and gates to one-inch diameter by ten feet long ground rods, buried three feet outside fenced area, using ground cable sized minimum 2/0 and clamps as indicated in the Contract Drawings. Fence grounding shall be independent of the traction power facility ground grid.
  - 2. Install braided flexible jumper at open fence joints and gates for continuity to ground.
  - 3. Ground other metallic frames of non-current carrying structure to main station ground grid, using minimum No. 6 bare copper wire.

**3.09 LIGHT FIXTURE GROUNDING**

- A. Unless otherwise specified, provide the housing of each ballasted lighting fixture with a separate, factory-installed grounding device.
- B. A separate grounding conductor shall be attached to the grounding device on each fixture housing and connected to the ground lug terminal in the hand hole of the light pole.
- C. Fluorescent fixtures connected end-to-end shall have a common ground conductor between them to provide a continuous ground path.

- D. Light poles shall be grounded by use of a separate grounding conductor connected at one end to the grounding lug in the hand hole of each pole, and the other end connected to either the steel rebar of the pole foundation or directly to the ground grid.

### **3.10 RACEWAY GROUNDING**

- A. All metallic raceway systems shall be bonded together to provide a continuous electrical ground path. Metallic raceways shall be bonded to other raceway components using insulated grounding bushings. Grounding bushings shall be connected to the grounding system using conductors sized in compliance with NEC, CEC, and as specified on the Contract drawings.
- B. Metallic conduits shall be electrically and mechanically continuous and connected by bonding to the grounding system.
- C. If metallic raceways terminate at metal enclosures without mechanical and electrical connection to the enclosure, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to ground bus or terminal in the enclosure. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless specified otherwise.
- D. Ground conductors shall be provided in non-metallic raceway systems (unless they are designated for telephone and data cables) in accordance with the NEC and CEC.
- E. Install separate ground conductor across flexible connections.
- F. Metallic conduit containing only grounding or bonding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.
- G. Install all ground bushings and incidentals.
- H. Provide liquid-tight flexible metallic conduits with a continuous copper bonding conductor spiral wound between convolutions, as required by the NEC and CEC.
- I. Mounting hardware, associated with non-current-carrying conductive boxes, conduits, and cable tray systems in which dc cables are routed, shall be electrically isolated from the building and/or structure.
- J. Metallic Cable Trays
  - 1. Metallic cable trays shall be electrically and mechanically continuous.
  - 2. Install bonding jumpers at all cable tray connections.
  - 3. Connect each isolated metallic cable tray system or the entire cable tray system to the building grounding systems with a bare copper conductor in accordance with the NEC, CEC, and NEMA VE 1 and VE 2.

4. Base size determination of ground cable on the largest power and control conductor in the cable tray and to withstand the maximum short circuit current:

- a. Minimum Size: - 14 AWG.
- b. Maximum Size: - 750 kcmil.

### **3.11 UNDERGROUND DUCTBANKS AND STRUCTURES**

- A. Provide at least one driven ground rod at each underground structure. Set the ground rod depth with four inches exposed above the finished floor. Seal floor opening with waterproof, nonshrink grout.
- B. All non-current carrying conductive parts within underground structures shall be grounded. Train conductors level or plumb around corners and fasten to the walls of the underground structure. Size the ground conductor in accordance with the NEC and CEC, but shall be at least No. 6 AWG.

### **3.12 ELECTRICAL SERVICE SYSTEM GROUNDING**

- A. Grounding and bonding for the electrical service shall be provided in accordance with the electric utility service provider's requirements.
- B. The electric utility service provider's ground loop shall be isolated, insulated, and physically separated from the AC system ground mats, if physically possible.
- C. Grounding and bonding for pad mounted transformers shall be provided in accordance with the electric utility service provider's requirements.

### **3.13 BONDING AND GROUNDING OF COMMUNICATIONS EQUIPMENT RACKS, CABINETS AND ENCLOSURES (E.G. CO3, CO4)**

- A. Ground and bond racks, cabinets and enclosures per the manufacturer's recommendations, NECA 607 and the Contract drawings.

### **3.14 FIELD ENGINEERING, QUALITY CONTROL AND TESTS**

- A. Field engineering, quality control and testing shall be performed in accordance with the requirements of the following:
  1. Section 01 43 00, Quality Assurance.
  2. Section 01 45 00, Quality Control.
  3. Section 01 71 23, Field Engineering.
  4. Section 34 21 80, Traction Power System Field Acceptance Testing.

**B. General**

1. The existing ground grids shall remain.
2. Submit field test, plans, procedures and pre-printed test data sheets in accordance with Section 34 21 80, Traction Power System Field Acceptance Testing.
3. Furnish equipment for testing the grounding and bonding system after installation, including service test kit.
4. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not available, use those specified in UL 486 A&B or NECA recommendations.
5. Confirm that the installed grounding and bonding system is in conformance with the approved drawings.
6. Inspect for physical damage, and tightness of connections, defective wiring, and general mechanical and electrical conditions.
7. All non-conforming work shall be reworked by the Contractor at no additional cost to the District.

**3.15 FIELD QUALITY CONTROL****A. Ground Resistance:**

Test the grounding system by the three-point fall of potential method under the observation of the Engineer. Ground resistance measurement test shall be made in normally dry conditions not less than 48 hours after the last rainfall. If the test is influenced by nearby ground grid, then the test shall be repeated by locating reference electrode to a longer distance until interference is minimized.

1. Each ground rod shall be tested individually before connecting them together to make grid. Resistance of each ground rod shall be tested to verify it is 25 ohms or less.
2. Testing shall verify that ground grid resistance corresponds to the grounding grid calculation.
  - a. Do not place backfill, install subgrade, or pour concrete above ground grid, ground rod, ground conductors, or ground connections until inspection by the Engineer is completed, testing of the grounding system is complete, and the grounding installations are approved.
  - b. Do not exothermically weld the ground grid system to the invert slab rebars for the purpose of meeting the ground resistance requirement criteria.

**B. Ground System Continuity:** Test equipment enclosures, conduit, raceways, exposed expansion joints, lighting fixtures, receptacles, light standards, steel stairs, handrails and non-current carrying conductive entities for continuity to the ground system.

1. Test the electrical resistance of each exothermic welded connection in accordance with Art. 3.03 I of this Section.
2. Test all GFCI receptacles and circuit breakers for proper connection and operation with methods and instruments prescribed by the manufacturer.

C. Test Reports

1. Submit to the Engineer a certified written record of inspections, test, and detailed test results in the form of a test log, on the satisfactory completion of tests. All equipment and other components at which tests have been satisfactorily completed shall be tagged to indicate completion of testing.

**3.16 SYSTEMS INTEGRATION TESTING**

- A. Refer to Section 20 80 00, Systems Integration Testing, for requirements.

**3.17 CLEANING**

- A. Refer to Section 01 74 14, Cleaning, for additional requirements.
- B. Remove all waste material from the Jobsite(s) at no additional cost to the District.

**3.18 DEMONSTRATION AND TRAINING**

- A. Refer to Section 01 79 00, Demonstration and Training, for additional requirements.

**3.19 CLOSEOUT PROCEDURES**

- A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Contract Record Documents, for additional requirements.

**END OF SECTION 34 21 60**